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ORIGINAL ARTICLE

Identification of coordination factors affecting building projects performance

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Abstract Construction projects performance requires improvement to fulfil the complexity of the stakeholders' needs and expectations. Coordination process is proposed as an efficient solution for weak performance of construction projects. Therefore, coordination factors are vital in ensuring a successful implementation of all project phases. This study aimed to identify and prioritise coordination factors that influence the performance of building projects in Malaysian context. A vast body of literature on coordination process was reviewed and resulted in 53 coordination factor. Three rounds of Delphi technique were conducted. The most effective coordination factors were ranked based on the Relative Importance Index (RII) such as Scheduling (RII = 0.97), Quality assurance plan (RII = 0.93), and all parties' participation in plans (RII = 0.89). These coordination factors have fulfilled the research gap and provided better management and higher performance for project parties. The results offer insightful perspectives to define the most effective coordination factors, for addressing the dependency between project tasks and the parties to enhance project performance.

1. Introduction

In the past fifty years, the construction industry has changed tremendously in terms of size and complexity of the projects. Currently, many construction projects have a complex design of electrical and mechanical installations, employ sophisticated structure systems and serve the diversified requirements of different end-users. The project complexity is a result of the industry fragmentation, which requires effective coordination between the project parties. In addition, construction projects are unique in nature, and involve myriads of interrelated activities and work packages [1]. Project parties deal with large amounts of information derived from various stakeholders, such as owners, designers, contractors, subcontractors, suppliers, banks and governmental units. Thus, accessing the required information at the right time and location is rather difficult in such circumstances. Therefore, construction projects have commonly suffered from poor quality and productivity, cost and time overruns [2,3].

Construction industry has extensive linkages with the rest of the economy, for example, the manufacturing industry and financial services industry. This industry is responsible for building the nation's physical infrastructure, providing

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transportation facilities, accommodations, businesses, and institutions. Over the past decade, the Malaysian construction industry has contributed significantly to the economy as an enabler of growth to other industries [4]. The Construction Industry and Development Board (CIDB) reported that the value of construction projects awarded in 2015 reached USD 28.72 billion and estimated that, it would be USD 32 billion in 2016 [5,6]. Moreover, the construction industry represents nearly 3–5% of the total Gross Domestic Product (GDP) and provides employment for about 10% of the total Malaysian labour force [7–9]. Building construction is considered to be an essential element of the construction industry in Malaysia, and it forms about 64.6% of the overall construction work [6].

Project completion on time, standard of quality and within the assigned budget are the common goals of construction projects. However, there is lack of a proper coordination practice amongst construction parties. Moreover, many problems may be encountered on a large construction projects, making it necessary to coordinate the efforts of the involved parties, including the owner, contractors, designers, suppliers as well as local authorities. Although the coordination process has not been clearly defined [10,11], it is regarded as one of the critical project management functions that determines the appropriate actions in the successful project completion. It has been widely recognised that the coordination process influences the project performance and eventually affects the project's success [12–14]. In order to manage a building project efficiently, the coordination process must be applied as one of the essential functions in project management. The purpose of the coordination process is to add value to project delivery and to improve efficiency by dealing with the dependencies between project tasks and parties, in other words, "*Managing dependencies between activities*" [15,20].

Coordination factors are considered as the main components of coordination process, which affect the performance of building projects. Furthermore, to improve the coordination amongst construction parties, it is important to identify these factors. Furthermore, in construction projects, contractors are the major role players in construction sites, to satisfy the owner's objectives against reasonable profit, under the consultant supervision. Thus, all parties are required to coordinate the tasks before and during the construction phase to ensure its successful delivery [20].

An increasing number of studies have investigated the importance of the coordination factors in other industries, such as computer science and car manufacturing [16–18]. Meanwhile, it has been found that the construction industry has a discouraging record of performance during the past decades, owing to the lack or inefficiency of coordination process [12], whilst, in the Malaysian construction industry, objective studies in identifying and assessing coordination factors are scarce. Therefore, an objective study to identify the effective coordination factors for building projects is urgently required [12].

This study covers the gap of unidentified and non-prioritised coordination factors affecting construction projects' performance in Malaysia [19]. The significant contribution to body of knowledge of this study is that, it is the first study to identify and prioritise coordination factors affecting building projects performance in Malaysia. To achieve this, Delphi technique was used to rank the identified coordination factors from the related literature. The Delphi technique is a survey method used for obtaining the opinion of experts in a number of consecutive rounds [21]. The information obtained in a round is used as a basis for the questionnaire of the next round, with a high degree of anonymity about each expert response [22]. In fact, many researchers utilise this method in identifying critical factors and improving the performance of construction projects [23–25].

2. Literature review

Coordination is one of the major considerations in managing building projects and an essential contributor for projects success and objectives achievement. Besides, the coordination best practices in the Malaysian construction projects can be enhanced significantly, once the effective coordination factors are identified through knowledge explicating and sharing [42–45,12,26]. However, construction projects performance status is not affected only by coordination, and also by a large number of elements that could be related to various dimensions such as projects managers' competence, top management support, monitoring and feedback by the participants and decision-making process [40]. On the other hand, the coordination of building projects has significant impacts on various aspects of the project outcomes [12–14,27–30].

It is difficult to establish a clear definition of coordination theory. This is because coordination can be derived and used in the theoretical context of the coordination theory, which is known as "*a body of principles about how the activities of separate actors can work together harmoniously*" [31]. At the same time, the term coordination can also be used in its more common meaning rather than in the theoretical context of the coordination theory [32]. When discussing coordination, practitioners usually refer to the condition of dependency, connections or hard to work together [33,34]. Nevertheless, coordination factors in construction projects can be defined as a body of procedures such as detailed procurement plan, resources priorities for critical tasks, and task dependencies identification and components such as plans, meeting and reports of an effective coordination process to provide a harmonious working environment. It is important to realise that there is not yet a solid definition of coordination factors in this domain [20,12].

The factors for a successful coordination process have been studied and grouped under three dimensions: *mandate, systems* and *behaviours*. Therefore, if these factors in the three groups are recognised with enough importance and are put in place over time, the success of the activities is more likely and will occur sooner [20,35]. Basically, a series of coordinated activities are triggered since the project is an idea and needs continued coordination during the implementation stages until objectives achievement. Some of these activities require support from various parties to improve the project progress with a high satisfaction status, e.g. coordination meeting [31].

Developing the coordination process has been purposed for the investigation in [36]. The coordination factors were based on the roles and responsibilities of key parties or a set of coordination procedures required combining the knowledge, expertise and information of many parties that support project optimisation. The identified coordination factors were, well-developed relationships amongst key implementation parties, sharing vision amongst the operators and service providers for project deployment activities, testing and verifying performance after every action completion, confidence and trust amongst agencies, and meetings to exchange ideas and dealing with conflicts. The coordination factors in management of the temporary organisations to ensure the effectiveness performance were argued in detail in [37]. The factors included dependence and sharing as the two main issues. The most important coordination factors in the study comprised from enhancing dependences' determination to facilitate the work, sharing experience in implementation approaches and concerning work methods, reporting on the developments and progress, and written correspondence, such as letters and memos, including written contract clarifications [37]. The previous factors were more in general management concepts, rather than in construction projects.

In construction projects, due to coordination factors consideration between project actors, a significant performance improvement has been observed [5]. The coordination issue in the human resources of the projects has been addressed directly. The factors were e.g., "*better communication and integration between project actors*". The organisational skill to improve vertical and horizontal information flows amongst project actors and an alternative resource sharing mechanism would be needed to manage resources if multiple actors could work on the same project, which is also an important factor in coordination process.

Coordination process investigation in Indian construction industry led to 59 coordination factors [19]. The primary factors have been created through interviews with experts. In the next stage, the less important factors have been eliminated by a questionnaire survey, which conducted amongst Indian construction professionals. After analysis, RII has been calculated. The seven highest factors that affect significantly in enhancing project coordination¸ have been selected. The study found that, contract and agreement implementation, follow up between parties, preparation of project quality and estimation of the optimum resource requirements have the highest effects on project performance [11,38].

There is a strong argument of relationship between building procurement methods and the coordination of building services [39]. The selection approach of the procurement method and its effects on the coordination process is highly correlated. The root causes of the poor coordination of building services association with unsuccessful procurement were proved. The coordination of complex and highly serviced buildings (e.g., large hospitals, offices and hotels) is always fraught with complex problems of inadequate coordination process. Furthermore, three case studies of large hospitals in Hong Kong were investigated to determine the coordination factors. The factors are considered as effective guidelines, routes for highly serviced buildings, and for the building industry to implement the management of projects more effectively. The most important factors were intensive inputs from clients, complete design information, effective site procurement and management, and contract conditions (i.e., allocation of risks, responsibility of liquidated damages) [19].

Site coordination is essential to enhance construction projects performance. In Hong Kong building projects, sixteen coordination factors were classified into three groups: staffing, technical and management system [12]. The most effective factors reported are sufficient technical support from head office, sufficient site office space, good phasing of work and clear communication path. It is concluded that more efforts are needed in the construction management systems, especially in communications, to develop the coordination process.

In summary, the previous studies provide useful perspectives to understand the coordination factors to be applied in construction projects. However, most of the factors were related to other industries and none of them covers the gap, to identify and prioritise coordination factors in Malaysian building projects. Fifty-three (53) coordination factors were identified from the above literature review and presented in Appendix A. These factors represent the milestone of coordination framework and a solid platform for coordination process in building projects. The factors were classified under five main groups. The groups are (i) Planning and Scheduling, (ii) Resource Management and Contacts, (iii) Records and Documentation, (iv) Contract Implementation, and (v) Quality and Value Engineering.

The prioritised process is based on RII criteria, which has been adopted by many researchers [12,14,16,30]. From their implementation of RII, it has been observed that this method is mostly adopted in construction projects' critical success factors.

3. Research methodology

The Delphi technique is a survey method, which is being increasingly applied in many complex areas to reach a consensus amongst experts through intensive questionnaire rounds. The Delphi technique has been used for a few decades in different research areas, such as strategic planning, health, and social science fields. However, its applications in the construction sector have only been considered recently [21,23]. Delphi method has been introduced as a strong and reliable technique in construction management research, with valid and accurate results. The technique typically involves the selection of suitable experts, development of an appropriate questionnaire and analysis of the responses through more than one round [22,24]. In this research, Delphi technique was used to justify the research aim in identifying the effective coordination factors which affect the building project's performance.

Furthermore, all information that could help in achieving the study objectives was collected, reviewed and formulated to be suitable for the study context. The identified fifty-three (53) factors were discussed with professionals from construction industry before developing the questionnaire instrument. The preliminary list of coordination factors was presented to academic and industrial experts during face-to-face interviews. All selected experts had more than 10 years' experience within construction project management. The interviews were conducted in the interviewees' offices, and lasted for 1/2 to 1 h. All the professionals agreed that the proposed factors were effective and comprehensive, meanwhile, valuable comments on the scope and validity of the factor statements had been provided. For example, all the factors were requested to be summarised as keywords and to be followed by descriptions for more explanation. The final and revised coordination factors were classified into five groups, in such a way that factors in the same group are more similar (in some sense or the another) to each other than to those in other groups. The main justification of grouping is to simplify the investigation process of the factors, in divided groups rather than in one block set. Also, this grouping approach made the questionnaire used in Delphi technique during the ranking process easier for the experts in terms of understanding.

The questionnaires were comprised of two main sections. For Section 1, there are six questions related to the respondents' profile and the organisations' characteristics. Section 2, included five groups assigned to the coordination factors. Prior to conducting the actual questionnaire phase, a pilot study was carried out to test its suitability and comprehensibility. Through this trial run of the questionnaire, the effectiveness of the standard invitation to the respondents was measured. Five project managers, one client, two consultants and two contractors were prompted to answer the questionnaire. All proposed advice and comments were considered and discussed. The previous methodology led to the final data collection stage using the Delphi technique as shown in Fig. 1.

As mentioned in the section of the literature review, there is no consensus on the coordination factors in Malaysian building projects. The Delphi technique is designed to obtain the most reliable consensus from a panel of experts by a series of questionnaires interspersed with controlled opinion feedback, and with the results of each round being fed into the next round [21]. Even if these collective judgments of experts are made up of subjective opinions, it is more reliable than individual statements, thus, more objective in its results. Testing for the reliability of a scale, Cronbach's coefficient alpha was used to examine the internal consistency of the scales. The results of the test were compared with the critical value of the test (0.7) to measure the reliability.

The Delphi technique was designed to minimise biasing effects of the dominant individuals, irrelevant communications, and group pressure towards conformity. The number of rounds could be varied between two and seven [21,22]. Too many rounds would waste the respondents' time and too few rounds could yield meaningless results. In order to reach an acceptable and stable degree of consensus, the majority of the studies have used three rounds, and involved 15–30 respondents [24]. The procedure of the three rounds of Delphi was applied in this study and was discussed in detail in the following sections.

3.1. Selection of expert panel

The success of the Delphi technique principally depends on the careful selection of the experts' panel. However, there are no hard and fast rules about the minimum number of experts.

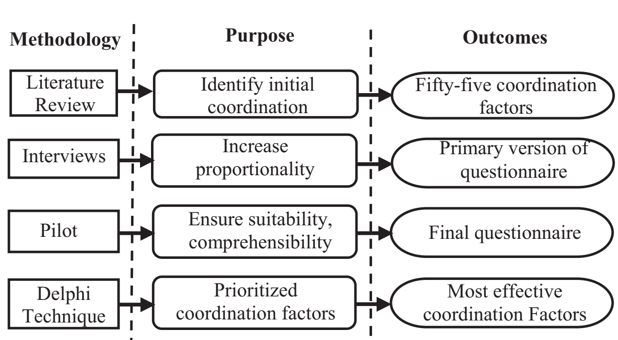

Figure 1 Research framework of the study.

For example, Hasson and Keeney [22] suggest that ten to fifteen expert could be sufficient if the background of the Delphi subjects is homogeneous. In contrast, if various reference groups are involved in a Delphi study, more subjects are anticipated to be needed. On the other hand, representation is assessed by the qualities of the expert panel rather than its numbers, whilst, Ludwig [25] documented that, "the majority of Delphi studies have used between 15 and 20 respondents". Therefore, the decision about panel size is empirical and pragmatic, taking into consideration factors such as time and expense. In order to meet all the stipulated requirements and to increase the efficiency of the outcomes, the sample size was 28 respondents, representing a wide distribution of professionals from several disciplines including both public and private sectors, in addition to academic experts, and the selection of the panellists was important for validity considerations. In this study, the Delphi technique panellists who met the criteria of having sufficient working experience or knowledge in the building projects' field, or working in relevant organisations in the building industry were selected. However, the panellists of this study were professional engineers with more than 10 years working experience together with advanced academic qualifications. Therefore, the selected panellists were qualified enough to provide the necessary information to achieve the study objectives. Table 1 presents the positions, experience and education, of the experts who met the selection requirements and agreed to participate in the Delphi technique in this study.

3.2. Round 1: Listing and ranking coordination factors

The first round of the Delphi technique is crucial important and was conducted for the exploration process. Every expert was required to list the coordination factors based on their own knowledge, if it is not included in the questionnaire and to delete the irrelevant factors as well. After the completion of the first round survey, the measures were carefully analysed and a list of ranked coordination factors was formed. At this stage, a five-point Likert scale was used, which ranged from 1 'not important', 2 'less important', 3 'moderate', 4 'important', and 5 'very important'. In this research, the mean score

Table 1 Respondents' profiles, frequency and per cent.

Profile alternatives	Frequency	Per cent (%)
Position of respondent in organisation		
Director/deputy	10	35.00
Project manager	6	21.40
Professor	4	14.30
Assistant professor	2	07.10
Other e.g. Designer	6	21.40
Years of experience (years)		
From 5 to less than 10	12	42.90
From 10 to less than 15	2	7.10
From 15 to less than 20	6	21.40
More than 20 years	8	28.60
Level of education		
PhD.	6	21.40
Master.	10	35.70
B.Sc.	12	42.90

of 3.0 was adopted as a cut-off point. The collected data were analysed and the mean score was calculated. Therefore, any factor mean score less than 3 was deleted from the factors list (5 factors were eliminated),

3.3. Round 2: Ratings obtained from the experts

The purpose of the second round was to begin the process of consensus building amongst the panellists, based on the importance of each coordination factor. A list of the remaining coordination factors (48 factors) with their explanations and expert-frequency was provided to the experts for their reference. The panellists were asked to re-rank the factors in the light of the difference between their previous rank and the mean (M) of the group ranks. However, in order to obtain a measure of consistency, Kendall's Coefficient of Concordance (W) was calculated with the aid of the Statistical Package for Social Sciences (SPSS) software. Kendall's coefficient of concordance indicates the current degree of agreement amongst the panellists on the ordered list by taking into account the variations between the rankings [40]. According to the level of significance, which was less than 0.05, the null hypothesis that the respondent's ratings within the group were unrelated to each other would be rejected. A significant agreement amongst the respondents was reached. Only the measure that was regarded as moderate remained for the re-evaluation in 3rd round, so that 17 factors were eliminated.

3.4. Round 3: Re-assessment and final ratings

In the third round, the experts were asked to re-assess their ratings in the light of the consolidated results obtained in round two, based on the new list of the remaining factors (i.e. 31 factors). Most of the experts had reconsidered and adjusted their ratings. In addition, Kendall's Coefficient (W) was used as a concordance indicator in this study. The increment in values of Kendall's Coefficient of Concordance (from 0.513 in the previous round-2nd round-, to 0.652 in this round-3rd round) indicates that the agreement level amongst the panel experts had improved. The flow chart procedure of the Delphi technique in this study is shown in Fig. 2.

In this study, the procedure of the Delphi technique summed up to three rounds. In the first round, the respondents were asked to rank the coordination factors and to add to the list, if any, from their own opinion. In the second round, the respondents were provided with the consolidated results from the first round and were asked to provide ratings to all the coordination factors without adding any new factors. The seven least measured factors were excluded from the next round based on a criterion that all the factors were selected by at least 50% of the experts as least important, based on a five-point Likert scale.

In the third round, the experts were asked to reconsider the ranking of the factors for the last time, after they were provided with the second round results. The obtained raw data were input and analysed with the aid of the SPSS software. These methods had been used by other similar survey studies [21,25,28]. The relative importance of the most effective coordination factors was explored based on the responses. This type of scale has been found to be acceptable in several construction management researches [40,41].

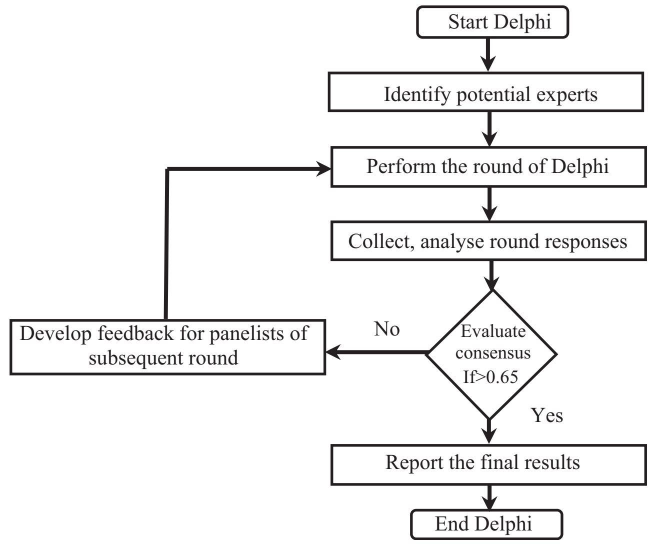

Figure 2 Delphi technique flow chart.

In order to examine whether the respondents ranked the 16 coordination factors in a similar order, Kendall's coefficient of concordance was calculated. According to Hai et al. [42], if the concordance coefficient is equal to 1, it means that all the respondents ranked the coordination factors identically; in contrast, if the concordance coefficient is equal to 0, it means that all the respondents ranked the factors totally differently. Kendall's coefficient of concordance for ranking the 16 coordination factors was 0.65, which was statistically significant at 1% level of confidence. This indicates that a general agreement amongst the experts on ranking the coordination factors was achieved, as the respondents shared similar values about the relative importance of these factors.

Testing for reliability of a scale, Cronbach's coefficient alpha was used to examine the internal consistency of the scales. Alpha values greater than 0.7 were regarded as sufficient. The results of Cronbach's coefficient alpha in this survey were in the range of 0.87–0.88. This provides confidence in the results and their application in future studies [7,28].

4. Results and discussion

The Delphi technique was used in this research to build a consensus about the coordination factors. It was composed of three rounds with 28 experts from different construction parties (contractors, consultants and owners) as well as academic experts. The experts represented a wide spectrum of construction professionals in Malaysia and provided a balanced view. Furthermore, most of the experts hold senior positions in their organisations and have advanced academic qualifications. Table 2 presents the results of the final Delphi survey. The coordination factors were classified into five groups and three columns of the results, present M and RII and the rank based on the importance.

The analysis of the third round of the Delphi survey's data shows that the standard deviations of all factors were less than 1 and the mean standard deviation was 0.69. This means that a reasonable and acceptable consensus was achieved. Only the factors with a mean value of 4.20 or more and RII more than

Table 2 The final coordination factors.

Group	Factors	M	RII	Rank
Planning and scheduling	Plans (use or write briefing of project execution approaches, such plans cover those delivered by the owner/contractor/consultant)	4.69	0.82	4th
	Scheduling (prepare and update schedules to convey time related information, based on the new and actual events)	4.88	0.97	1st
	Meetings (to exchange ideas, deal with conflicts and facilitate work, such as regular/irregular meetings)	4.64	0.77	5th
	All parties' participation in plans (Liaison and communication with specialist consultants, specialist subcontractors and nominated subcontractors to be involved in plan)	4.74	0.89	3rd
Resource management and contacts	Joint site visits (which are used to inspect a project's performance by gathering, sharing, or confirming information on-site)	4.58	0.74	6th
	Team spirit (developing and receiving constructive inputs from all participants with an open mind)	4.26	0.55	13th
	Communication channels (open wide and fast communication channels amongst all parties, structured or unstructured)	4.53	0.70	7th
Records and documentation	Record maintenance (all drawings, information, directives, verbal instructions, and documents received from each party to others, hard/soft copies)	4.51	0.74	6th
	Drawing documentation (for overlapping activities' coordination and giving execution plan of responsibilities to all parties involved)	4.30	0.58	12th
Contract Implementation	Contract documents (understanding generally, including contract articles, drawings, and specifications as complementary documents)	4.34	0.61	11th
	Maintaining contracts (documents and amendments to contracts, and obtaining specifications, and technical details)	4.20	0.50	15th
	Cleared payments (appropriate with contract specified limits; consistent with the work progress state)	4.41	0.66	9th
Quality and value engineering	Work integration (from different subsystems and subcontractors to agree on detailed construction methods' specifications)	4.47	0.69	8th
	Design and specification clarity (rights/ constraints; to assign adequate time and resources for project implementation)	4.37	0.64	10th
	Quality assurance plan (Prepare for the project in line with contract specification)	4.81	0.93	2nd
	Value engineering (find new alternatives for higher specifications with less cost)	4.23	0.53	14th

0.50 were considered. Based on this criterion, 16 factors were selected and classified into five main groups as shown in Table 2. The mean values for factors (M) were in the range of 4.20–4.88 and RII of 0.50–0.97.

The analysis of the survey response data represented the means and RII of the factors, which indicated that all experts had consensus on these 16 factors as being critical for Malaysian construction projects' performance. The highest ranking by all respondents was the *Scheduling (prepare and update schedules to convey time related information, based on the new and actual events)* (M = 4.88), which, therefore, was considered as an extremely influential factor to the project success. As a comparison to study that had been carried out by Neeraj Jha and Misra [19], this factor scored as the second ranking in the planning group of Indian construction projects. On the other hand, the factor was the fifth order in coordination activities in the Hong Kong and Singapore construction industries, which had been identified by Saram and Ahmed [46]. *Quality assurance plan (Prepare for the project in line with contract specification)* was ranked as the second important factors (M = 4.81). The above result of the Quality plan factor is consistent with Neeraj Jha and Misra's [19] study and scored the first factor in the quality group. *All parties' participation in plans* (*Liaison and communication with specialist consultants, specialist subcontractors and nominated subcontractors to be involved in the plan*) (M = 4.74) was ranked as the third most influential factor. In contrast with Neeraj Jha and Misra's [19] results, this factor is not presented in the top 20 factors. In Saram and Ahmed's [46] study it was in the 12 order. The fourth order was occupied by *Plans* (*use or write briefing of project execution approaches, such plans cover those delivered by the owner/contractor/consultant*) with M = 4.96. However, planning had the same rank in Neeraj Jha and Misra's [19] study and the eighth ranking in Saram and Ahmed's [46] study. The fifth ranked order was also occupied by *Meetings* (*to exchange ideas*, *deal with conflicts and facilitate work*, *such as regular/irregular meetings*) with M = 4.64. The factor occupied the third factor in Jah and Misra's [19] study and the eleventh factor in Saram and Ahmed's [46] results.

The sixth rank was occupied by two factors, Record maintenance (all drawings, information, directives, verbal instructions, and documents received from each party to others, hard/soft copies) and Joint site visits (which are used to inspect a project's performance by gathering, sharing, or confirming information on-site). Whilst Record maintenance recorded the fourth rank in Jah and Misra's [19] study, it scored the twelfth rank in Saram and Ahmed's [46] results. About Joint site visits factor, it occupied the seventh rank in Jah and Misra's [19] results; however, it was not involved in Saram and Ahmed's.

These factors were the most effective coordination factors affecting construction project performance in Malaysia.

Table 3 Results comparison with other studies.

Factors	This study ranking	Jah & Misra's [19]	Saram and Ahmed's [46]
Scheduling	1st	2nd	5th
Quality assurance plan	2nd	1st	15th
All parties' participation in plans	3rd	22nd	12th
Plans	4th	4th	8th
Meetings	5th	3rd	11th
Record maintenance	6th	4th	12th
Joint site visits	6th	7th	3rd
Communication channels	7th	6th	13th
Work integration	8th	10th	21st
Cleared payments	9th	8th	39th
Design and specification clarity	10th	9th	20th

Table 3 summarises the comparison of this study's results with Jah and Misra's [19] and Saram and Ahmed's [46] from the other side for ten factors.

Based on the previous comparison, the results of this study are more similar to Jah and Misra's [19] results, that was conducted in India, as compared to Saram and Ahmed's [46] results in Hong Kong and Singapore in terms of prioritising of coordination factors in Malaysian context.

In addition, it is worth noting, that *Team spirit*, *Value engineering*, and *Maintaining contracts* as the least influential factors in the selected 16 factors are shown in Table 2.

5. Conclusions

The importance of the coordination process has been recognised by scholars and professionals in the construction industry as well as in other industries. A strong relationship between coordination process and performance of construction projects has been highlighted by many researchers. Therefore, this study investigation on different aspects of the coordination process in different domains found that, various coordination factors were identified from the previous and the current literature. It is crucial to explore the relative importance and categorise these factors to improve the performance of building projects.

The findings of this study identified the most important coordination factors that can assist in enhancing the performance of construction projects in Malaysia and fulfil the research gap in the literature. Fifty-three (53) coordination factors were identified and highlighted from the area of construction project management as well as other disciplines. Face-to-face interviews and pilot study were conducted. Based on a three-round Delphi technique, the ranking of these factors was obtained. This helped clarify what the highly prioritised factors were. The top three factors from the 16 selected factors were as follows: Scheduling, Quality assurance plan, and all parties' participation in plans, Contract documents, and all parties' participation in plans. In contrast, the least influential factors were, the drawing documentation and value engineering.

In future studies, the same research procedure is required to be conducted in different types of construction projects like infrastructure. In addition, different locations that have different cultures need to be investigated to seek the similarities and differences of the coordination factors amongst them. As with any other opinion-based study, this study suffers from some limitations. As discussed in the "selection of panel experts" section, efforts were made to ensure that all the respondents were experts in the building construction projects. However, the effects of these limitations could be further reduced by taking a larger panel size, and by increasing the interaction between researcher and respondents.

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Appendix A

List of the 53 coordination factors used in the questionnaires:

Factor	Description
Group 1: Planning and scheduling factors:	
PLANS	Use or write a briefing of project execution approaches, such plans cover activities delivered by the owner/contractor/consultant
SCHEDULES	Prepare and update schedules to convey time related information, based on the new and actual events
INFORMATION AND DETAILS	Identifying/gathering, based on all parties' requirements and consolidating to be used in planning and scheduling before the project starting
SCHEDULE LEVEL OF DETAILS	Deciding the appropriate level to provide every party with the required information for their own planning and scheduling
FEEDBACK	To facilitate the improvement of plans and tracking job packages over time, as schedule requires continues update
DETAILED PROCUREMENT PLAN	Prepare completed plan for project procurement and preparation, such as Long Lead Items (LLIs)
RESOURCES PRIORITIES FOR CRITICAL TASKS	Identify critical activities to give them the priorities in resources allocation process
KICK-OFF MEETING	Arranging before project start with all parties to clarify and review scheduled of milestones for their area of activities
CRITICAL TASKS MONITORING	Regular monitoring of critical path activities for adhering schedule to prevent any delay
COMPLETED WORK	Handing over finished and

(*continued on next page*)

Appendix A (*continued*)

Factor	Description
TRACKING	approved parts of project for client using, with transferring its responsibilities to him
TASK DEPENDENCIES	Identify tasks dependencies using PERT or CPM network analysis to facilitate the planning and scheduling
MEETINGS	To exchange ideas, deal with conflicts and facilitate work, such as regular/irregular meetings
ALL PARTIES' PARTICIPATION IN PLANS	Liaison and communication with consultants, suppliers, and nominated subcontractors to be involved in the plan
Group 2: Resources management and contacts factors:	
FORMAL INFORMAL CONTACT	Face-to-face or over the telephone contact, for work facilitation discussion, emerging problems, or opinions exchange amongst different parties
JOINT SITE VISITS	Which are used to inspect a project's performance by gathering, sharing, or confirming information on-site
COMMUNICATION FREQUENCY	Increase based on the level of uncertainty and dependence, i.e. speed and amount of information transferred
EFFECTIVE ORGANIZATIONAL STRUCTURE	Establishing and maintaining them through clear communication channels
FORMAL/INFORMAL RELATIONSHIPS	Maintaining proper relationships between client, consultants and contractor, to facilitate project progress
SUB-PARTIES DECISION-MAKING	As subcontractors and supply chain members, for better forecasting of demand and information flow
INFORMATION TECHNOLOGIES	Proper usage which has the ability to import, process, store and disseminate information and could assist the integration of design information sharing and management)
MANPOWER ESTIMATION	Including the skilled labour for each task, and to be available for tasks implementation
RESOURCE ALLOCATION	Optimise resource utilisation by proper inventory materials and tools required, in efficient manner
HUMAN RESOURCES ARRANGING	Compliance with site instructions / directives from the supervisory team to ensuring effective utilisation
IDENTIFY APPROPRIATE RESOURCES	Materials and equipment purchases, delivery, storage and installation for some critical items, as pumps
TEAM SPIRIT	Developing and receiving constructive inputs from all participants with an open mind
COMMUNICATION CHANNELS	Open a wide and fast communication channels amongst all parties, structured or unstructured

Appendix A (*continued*)

Factor	Description
CONTACT PERSON	Assigned contact person from all parties in project, to be the links between them.
Group 3: Record and documentation factors:	
WRITTEN CORRESPONDENCE	Prepare and review letters and memos, including written clarifications, and review field reports
REPORTS	Describe work done in a period of time for documentation, including progress reports
RECORDS MAINTAINING	All drawings, information, directives, verbal instructions, and documents received from each party to others, hard/soft copies
OUTSIDE CONTRACT WORKS	Maintaining records of, variations, day works, and all facts/data necessary to support defence or claims
COVERED UP WORKS	Maintaining records of quantities of work done and details required for as-built drawings, as under plaster works
DRAWINGS DOCUMENTATION	Coordination and giving execution plan of responsibilities to all actors involved in project
Group 4: Contract implementation factors:	
CONTRACT DOCUMENTS	Understanding generally, including contract articles, drawings, and specifications as complementary documents
MAINTAINING CONTRACT	Documents and amendments to contract, and obtaining specifications, and technical details
DELEGATE RESPONSIBILITIES	For appropriate project participants especially on the site within the contract boundary, and follow up the delegated work
EXTERNAL CONTRACTORS	Arrange the works implemented by any company other than main contractor and his subcontractor
CONFLICTS RESOLVING	Amongst construction parties based on contract as early as possible, before worsen, as project suspension
BETTER ALTERNATIVES	Improving/altering/eliminating activities and considering alternatives that may efficiently meet the contract constraints
CLEARED PAYMENTS	Aperient within contract specified limits; in consist with the work progress state
Group 5: Quality and performance factors:	
WORK INTEGRATION	From different subsystems and subcontractors to agree on detail construction methods and specifications
OFF SITE FABRICATIONS	Manage and deliver them to the onsite work as; design modifications and change orders
DEFECTS	Gathering information on

Appendix A (*continued*)

Factor	Description
IDENTIFICATION	deficiencies/ambiguities, in drawings and specifications, and resolved them
OTHER PARTIES' LOGISTICS	Providing accommodation assisted project according to requirements as; storage space, scaffolding, plant, power, water, etc.
WORKS DONE BY OTHER	All relevant subcontractors should be warn to protect the completed parts
SITE INSTRUCTIONS	Compliance to directives from the relevant engineer and revising working programs accordingly
ARRANGING TESTS	For timely carrying out of all tests, inspections and approval by the engineer
CORRECTIVE ACTIONS	Informing/Communicating instances of poor quality, situations with relevant parties
DESIGN AND SPECIFICATIONS CLARITY	Rights/constraints; to assign adequate time and resources for project implementation
ALTERNATIVES IDENTIFICATION	In case of defect or damage, for remedial work methods and re-executing programs
MATERIALS SAMPLES	Arrange submission for approval by the supervision, in due time for approving process
QUALITY ASSURANCE PLAN	Prepare for the project in line with contract specification
VALUE ENGINEERING	Find new alternatives for higher specifications with less cost

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